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Full Length Research Paper

Measurement of exposure of radio frequency field (RF) radiation from global system for mobile communication (GSM) masts

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The objective of this study is to draw a conclusive position on the effect of radiofrequency (RF) radiation from GSM masts on human health. The measurement of the RF was conducted at 100 m and 200 m away from the masts of the major GSM operators in Nigeria; GLO, MTN and ZAIN. The data obtained were analyzed using correlation analysis to establish the fact that whether with time exposure to RF will have discernable effect on human health. The average amount of radiation measured from each GSM masts were 1.87, 2.26 and 1.48 µSv/h for 100 m and 1.50, 1.32 and 1.87 µSv/h for 200 m with their corresponding values of coefficient of correlation as 0.008, 0.004, 0.27, -0.027, 0.039 and 0.048 respectively. The study revealed that there is insignificant effect on human health because the non ionizing electromagnetic energy has no sufficient energy to affect any part of human body.

Key words: Radiation, radio frequency, human health, correlation, GSM masts, exposure.

INTRODUCTION

GSM is one of the fastest growing and most demanding telecommunication applications in the world today its present a continuously increasing telephone subscription around the world. Nigeria is one of the largest user of GSM equipment (mobile unit) in Africa, over 50% of the total population in Nigeria depend on the GSM as the easiest means of communication (ZAIN, 2005) but, Since the introduction of mobile phone in Nigeria the health implication of RF radiation from the base station has been a subject of great debate and concern among the Nigerian citizens. Some interested groups opine that radiation from base station (GSM) Masts are dangerous to health and some believed that to date, human health have the relationship between exposures to RF field. They also believed that exposure to radiation from base station for long period could cause different diseases like cancer, destroys reproductive organs, congenital anomalies, epilepsy and persistent headache. In Nigeria some of the base stations are planted right in a home of residence.

Some international communities also believed that exposure to RF have effect on two areas of the body like eyes and testes, are particularly vulnerable to RF heating because of the relative lack of available blood flow to dissipate the excessive heat load (Hyland, 2000). At relatively low levels of exposure to RF radiation, that is, levels lower than those that would produce significant heating; the evidence for harmful biological effects is ambiguous and unproven. Such effects have sometimes been referred to as “non thermal” effects. It is generally agreed that further research is needed to determine the effects and their possible relevance, if any, to human health (Kelly, 2005; Krzysztof, 2002; Zsolt, 2006).

Others also believed that there is risk of RF radiation to pregnant women; a pregnant woman and the foetus both are vulnerable because of the fact that these RF radiation continuously react with the developing embryo, increasing cells, because of the thermal radiation also when the pregnant ladies either use Mobile phone or when illuminated with RF radiation, the developing child can become affected, the developmental malformation may occur and it may also affect human brain; human brain is the most vulnerable portion to the NIEMR(RFR). Some of the known effects are Neurological effects, increase in ODC (Ornithin De Carboxylase) activity, effects on emzymes and free radicals decreasing the brain metabolism (Loque et al., 2004; Thomas et al., 2007; Persson, 1997).

Although some group like the International Commission on non ionizing radiation protection (ICIRP) and mobile

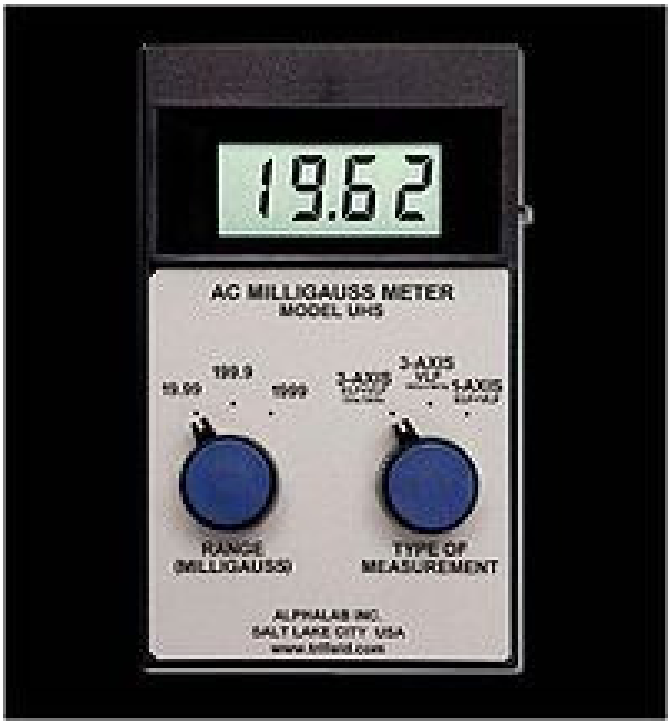

Figure 1. Electromagnetic (EMF) meter.

manufacturer forum (MMF) that manufactures mobile equipments and GSM operators across the world insists that there are no discernible effects from the base station radiation.

Therefore to confirm these positions whether there is scientific evidence or not to suggest that the low power emission levels are inimical to human or animal health; this now prompted the demand for this work.

However this work aimed at investigating relationship between exposures of radio frequency radiation from GSM masts and Human health mathematically (Correlation analysis), the work does not emphasis much on the laboratory experiment to check the associations.

MATERIALS AND METHODS

The materials/ instruments used in the study are measuring tape, stop watch and electromagnetic meter (Figure 1). The instrument has the following accessories 2 Kytes data memory, Audible pulse Ticker, Audio warning alert, Dosage expose chart, multi – function keypad, large digital LCD display, Reliable battery, both mrem/h and µSv units, wide temperature range (-40 to 70°C), and USB 2.0 data transfer port. In this work the instrument was calibrated to take measurements in µSv.

The three GSM Operator GLO, MTN and ZAIN antennas have general electrical properties; Gain (unity 3dBi), connector (multi – type option), VSWR (2:1), Bandwidth (broad band), Impedence (50 ohms), H-plane Beam width (omni directional), E-plane Beam width (100 degree), polarization (vertical), mounting (double side tape) and mechanical properties such as antenna cover (polyurethane), Operational temperature (-20 to +60°C), Storage temperature (-30 to +75°C).

Method of Data Collection

The data were collected from the three major GSM operator masts in Nigeria; all the masts are located at unguwar Lokowa/Barama Mubi North Adamawa State of Nigeria. For each of these masts the measurement was taken at 100 and 200 m in every 10 min for an hour in front, back and sides of the masts.

Method of data analysis

The data obtained were analyzed using correlation analysis to determine the coefficient of correlation between the exposure to GSM RF to human health and the period of exposure and Bar chart to analyzed the total amount of radiation obtained at each GSM masts. Equation (1) was considered to determine the coefficient of correlation.

$$r = \frac{\Sigma XY - \frac{(\Sigma X)(\Sigma Y)}{n}}{\sqrt{\left(\Sigma X^2 - \frac{(\Sigma X)^2}{n}\right)\left(\Sigma Y^2 - \frac{(\Sigma Y)^2}{n}\right)}} \quad (1)$$

Where r = coefficient of correlation.
X = Average amount of the radiation measured.
Y = Period of exposure to GSM RF radiation.
n = The number of terms (Ezeowu, 1990).

RESULTS

All the GSM Operators antenna were made to radiate 1800 MHz; they have the following specifications GLO, MTN and ZAIN have down link frequency of 1820 – 1835 MHz, 1835 – 1850 MHz, 1850 – 1865 MHz, uplink frequency of 1725 – 1740 MHz, 1740 – 1755 MHz and 1756 – 1770 MHz, respectively.

The analysis of the results were done by determining the coefficient of correlation and graphical analysis in other to establish the fact that whether exposure to GSM base station has effect or no effect on human health for a long period of time. The amount of radiation measured at 100 and 200 m is shown in Tables 1 – 6, the sum of all the radiations measured at 100m and 200m are given in Tables 7 – 9 and the coefficient of correlation of each measurement is indicated under Tables 10 - 15 which is calculated from Equation (1).

DISCUSSION

Point – to – Point microwaves antenna transmit and receive microwave signals across relatively short distance from a few tenth of kilometers to 48 km or more (Kelly, 2005). These antennas are usually circular in shape and are normally found mounted on a supporting tower, they are always place at a considerable height to provide clear and unobstructed line of sight (LOS) path

Table 1. Radiation from GLO masts at 100 m.

Y	X_1	X_2	X_3	X_4	X
10	0.45	0.41	0.30	0.27	0.36
20	0.40	0.40	0.25	0.21	0.32
30	0.21	0.40	0.20	0.21	0.26
40	0.40	0.45	0.40	0.20	0.26
50	0.45	0.40	0.40	0.20	0.36
60	0.40	0.30	0.30	0.25	0.31
3.5h	2.31 µSv/h	2.36 µSv/h	1.87 µSv/h	1.34 µSv/h	1.87 µSv/h

Field survey, 2009.
Y = Time taken during the measurement in minutes.
X_1 = Amount of radiation measured in front of the Antenna.
X_2 = Amount of radiation measured at the back of the Antenna.
X_3 = Amount of radiation measured at side 1 of the Antenna.
X_4 = Amount of radiation measured at side 2 of the Antenna.
X = Average amount of radiation measured across the all sides of the Antenna.

Table 2. Radiation from GLO masts at 200 m.

Y	X_1	X_2	X_3	X_4	X
10	0.25	0.20	0.20	0.40	0.26
20	0.20	0.10	0.20	0.20	0.18
30	0.20	0.10	0.30	0.32	0.23
40	0.40	0.20	0.31	0.31	0.31
50	0.30	0.40	0.32	0.27	0.32
60	0.20	0.10	0.21	0.28	0.20
3.5h	1.55 µSv/h	1.10 µSv/h	1.51 µSv/h	1.78 µSv/h	1.50 µSv/h

Field survey, 2009.

Table 3. Radiation from MTN masts at 100 m.

Y	X_1	X_2	X_3	X_4	X
10	0.60	0.40	0.40	0.40	0.45
20	0.20	0.40	0.30	0.40	0.33
30	0.40	0.30	0.30	0.30	0.33
40	0.50	0.35	0.40	0.20	0.36
50	0.40	030	0.30	0.60	0.40
60	0.45	0.30	0.40	0.40	0.39
3.5 h	2.55 µSv/h	2.05 µSv/h	2.10 µSv/h	2.30 µSv/h	2.26 µSv/h

Field survey, 2009.

between both ends of a transmission path or link. These antennas have a variety of uses, such as transmitting voice and data message and serving as link between broadcast or cable TV studios and transmitting antennas. The RF signal from these antennas travel in a directed beam from a transmitting antenna to a receiving antenna, and dispersion of microwave energy outside of the relatively narrow beam is minimal and this antenna transmit usually very low power levels, usually on the order of a few watts or less. The measurement were taken at ground level and the average amounts of radiation measured in this study are 1.87 µSv/h, for GLO, 2.26 µSv/h for MTN and 1.48 µSv/h for ZAIN at 100 m, 1.50 µSv/h for GLO, and 1.32 µSv/h for MTN and 1.37 µSv/h for ZAIN at 200 m in 3.5 h each. These measurements show that ground level power densities due to microwave directional antenna are normally a thousand times below recommended safety link (Thomas et al., 2007).

Table 4. Radiation from MTN masts at 200 m.

Y	X_1	X_2	X_3	X_4	X
10	0.25	0.19	0.19	0.20	0.21
20	0.21	0.25	0.25	0.30	0.25
30	0.30	0.25	0.25	0.20	0.25
40	0.30	0.15	0.20	0.20	0.21
50	0.27	0.10	0.19	0.21	0.19
60	0.25	0.15	0.18	0.24	0.21
3.5h	1.60 µSv/h	1.09 µSv/h	1.26 µSv/h	1.35 µSv/h	1.32 µSv/h

Field survey, 2009.

Table 5. Radiation from ZAIN masts at 100 m.

Y	X_1	X_2	X_3	X_4	X
10	0.25	0.11	0.20	0.26	0.21
20	0.27	0.20	0.25	0.21	0.23
30	0.25	0.25	0.30	0.20	0.25
40	0.20	0.20	0.25	0.22	0.22
50	0.49	0.20	0.30	0.22	0.30
60	0.30	0.25	0.28	0.25	0.27
3.5 h	1.76 µSv/h	1.21 µSv/h	1.58 µSv/h	1.36 µSv/h	1.48 µSv/h

Field survey, 2009.

Table 6. Radiation from ZAIN masts at 200 m.

Y	X_1	X_2	X_3	X_4	X
10	0.20	0.20	0.20	0.40	0.25
20	0.30	0.30	0.20	0.20	0.28
30	0.40	0.20	0.20	0.30	0.28
40	0.40	0.30	0.40	0.38	0.35
50	0.50	0.30	0.40	0.38	0.38
60	0.40	0.20	0.40	0.32	0.33
3.5 h	2.20 µSv/h	1.50 µSv/h	1.80 µSv/h	2.00 µSv/h	1.87 µSv/h

Field survey, 2009.

Table 7. Total amount of radiation from the three (3) major GSM operators at 100 m.

GSM operators	X	Y
GLO	1.87	1.00
MTN	2.26	1.00
ZAIN	1.48	1.00
Total	5.610 µSv/h	3.00 h

Field survey, 2009.

Table 8. Total amount of radiation from the three (3) major GSM operators at 200 m.

GSM operators	X	Y
GLO	1.50	1.00 h
MTN	1.32	1.00 h
ZAIN	1.87	1.00 h
Total	4.67 µSv/h	3.00 h

Field survey, 2009.

Table 9. Total amount of radiation measured at 100 and 200 m of GSM operator.

GSM operators	X	Y (h)
GLO	3.37	3.50
MTN	3.58	3.50
ZAIN	3.35	3.50
Total	4.67 µSv/h	10.50

Field survey, 2009.

Table 10. Analysis of radiation from the GLO masts at 100 m

X	Y	XY	X^2	Y^2
0.36	10	3.60	0.130	100.0
0.32	20	6.40	0.102	400.0
0.26	30	7.80	0.068	900.0
0.26	40	10.40	0.068	1600.0
0.36	50	18.00	0.130	2500.0
0.31	60	18.60	0.096	3600.0
1.87 µSv/h	3.5 h	64.80 (1.08) µSv	0.463 $\mu^2S^2v^2/h^2$	9100.0 (151.67) h^2

r = 0.008.

Table 11. Analysis of radiation from the GLO masts at 200 m.

X	Y	XY	X^2	Y^2
0.26	10	2.60	0.068	100.0
0.18	20	3.60	0.130	400.0
0.23	30	6.90	0.053	900.0
0.31	40	12.40	0.096	1600.0
0.32	50	16.00	0.102	2500.0
0.20	60	12.00	0.040	3600.0
1.50 µSv/h	3.5 h	53.50 (0.89) µSv	0.489 $\mu^2S^2v^2/h^2$	9100.0 (151.67) h^2

r = 0.0004.

In addition a recent research carried in July, (2009) on the review of the evidence on biological effects, epidemiological and health consequences concerning exposure to high frequency electromagnetic fields (100 kHz – 300 GHz) was conducted by ICNIRP standing committees in cooperation with its consulting members. It covers all scientific aspect relevant in this area which includes numerical dosimetry, measurements, biological laboratory investigation *in vitro* and *vivo* as well as epidemiological findings. One of their main conclusions of the review was 'Results of epidemiological studies to date give no consistent or convincing evidence of causal

Table 12. Analysis of radiation from the MTN masts at 100 m.

X	Y	XY	X^2	Y^2
0.45	10	4.50	0.203	100.0
0.33	20	6.60	0.109	400.0
0.33	30	9.90	0.109	900.0
0.36	40	14.40	0.130	1600.0
0.40	50	20.00	0.160	2500.0
0.39	60	23.40	0.153	3600.0
1.50 µSv/h	3.5 h	78.80 (1.31) µSv	0.864 $\mu^2S^2v^2/h^2$	9100.0 (151.67) h^2

r = 0.27.

Table 13. Analysis of radiation from the MTN masts at 200 m.

X	Y	XY	X^2	Y^2
0.21	10	2.10	0.044	100.0
0.25	20	5.00	0.063	400.0
0.25	30	7.50	0.063	900.0
0.21	40	8.40	0.044	1600.0
0.19	50	9.50	0.036	2500.0
0.21	60	12.60	0.044	3600.0
1.32 µSv/h	3.5 h	45.10 (0.75) µSv	0.2934 $\mu^2S^2v^2/h^2$	9100.0 (151.67) h^2

r = -0.0027.

Table 14. Analysis of radiation from the ZAIN masts at 100 m.

X	Y	XY	X^2	Y^2
0.21	10	2.10	0.044	100.0
0.23	20	4.60	0.053	400.0
0.25	30	7.50	0.025	900.0
0.22	40	8.80	0.048	1600.0
0.30	50	15.00	0.090	2500.0
0.27	60	16.20	0.073	3600.0
1.48 µSv/h	3.5 h	54.20 (0.90) µSv	0.371 $\mu^2S^2v^2/h^2$	9100.0 (151.67) h^2

r = 0.039

Table 15. Analysis of radiation from the ZAIN masts at 200 m.

X	Y	XY	X^2	Y^2
0.25	10	2.50	0.063	100.0
0.28	20	5.60	0.078	400.0
0.28	30	8.40	0.078	900.0
0.35	40	14.00	0.048	1600.0
0.38	50	19.00	0.144	2500.0
0.33	60	19.80	0.109	3600.0
1.87 µSv/h	3.5 h	69.30 (1.16) µSv	0.545 $\mu^2S^2v^2/h^2$	9100.0 (151.67) h^2

r = 0.048.

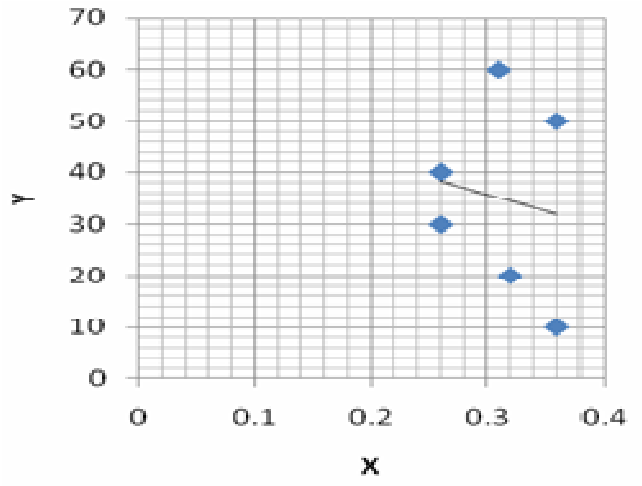

Figure 2. Analysis of radiation from GLO GSM masts at 100 m.

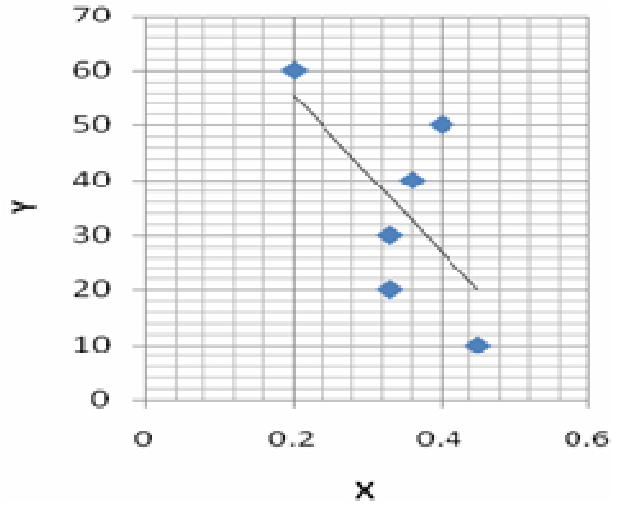

Figure 4. Analysis of radiation from MTN GSM masts at 100 m.

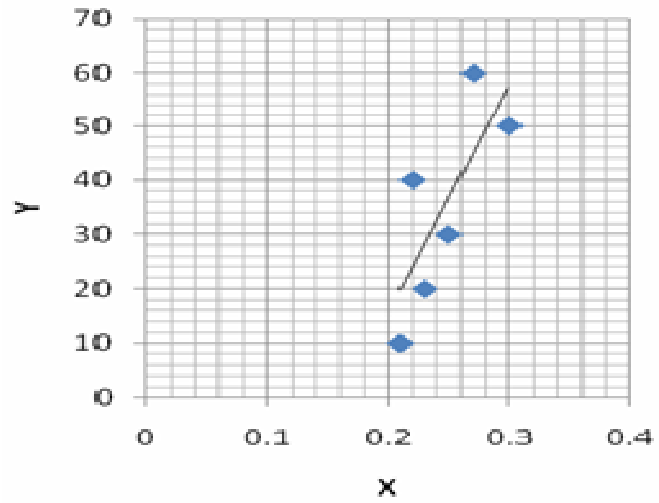

Figure 3. Analysis of radiation from GLO GSM masts at 200 m.

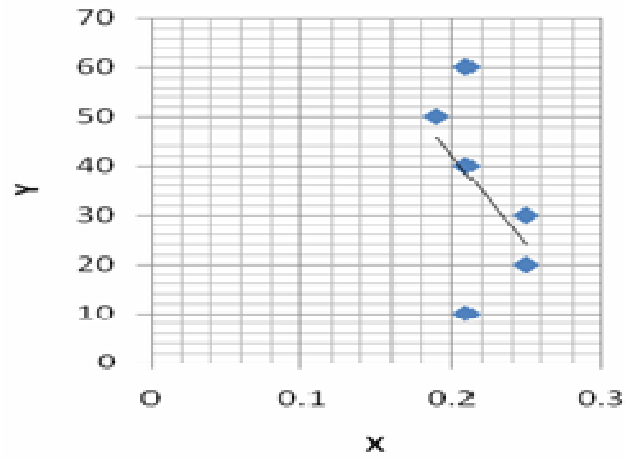

Figure 5. Analysis of radiation from MTN GSM masts at 200 m.

relation between RF exposure and any adverse health effect' (Mantiphy et al., 1999). Moreover as added margin of safety, microwave towers are in accessible to the general public because of its considerable height. Significant exposure from these antennas could only occur in the unlikely event that an individual has to stand directly in front of the antenna and very close to the antenna for a long period of time.

The analysis of the results in Figures 2 – 7 shows that there is an insignificant, negative and scattered correlation between exposure of RF radiation, human health and long period of time, with coefficient of correlation of 0.008, 0.004, 0.27, -0.0027, 0.039 and 0.048. The analysis in Figure 8 also shows that at 100 m and 200 m the average amount of radiation measured from MTN masts is higher than that of GLO and ZAIN

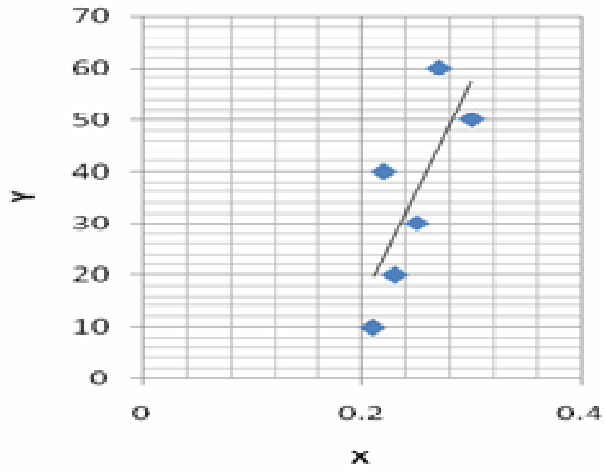

Figure 6. Analysis of radiation from ZAIN GSM masts at 100 m.

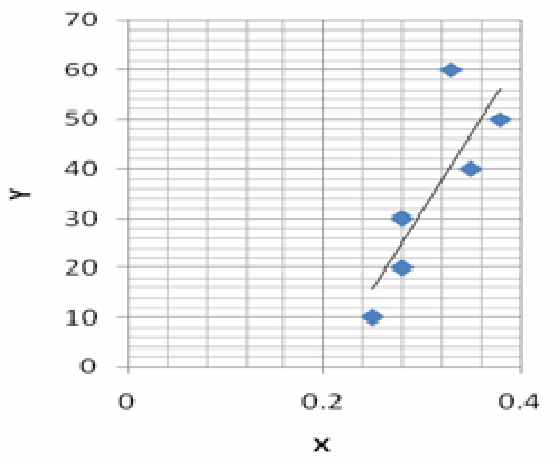

Figure 7. Analysis of radiation from ZAIN GSM masts at 200 m.

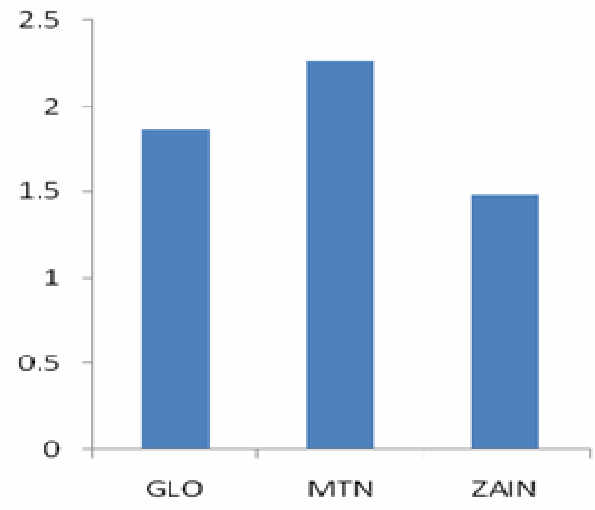

Figure 8. Total radiation measured at 100 m.

masts with ZAIN the lowest, however this is still far below safety level. Figures 9 and 10 shows that from the measurements the greater the distance the magnitude of the field reduces, the amount of the radiation is reduced by 0.37, 0.94 and 0.39 for GLO, MTN and ZAIN, respectively. The measurements also shows that at 1000 m (1 km) the radiation disappears completely meaning at that point no amount of radiation can be detected (Zero radiation). Figure 11 shows the frequency spectrum that indicated GSM frequency position while the micro wave towers are shown in Figures 12 – 14 for the three GSM Operators in Mubi.

Conclusion

The purpose of this study is to put an end to the great

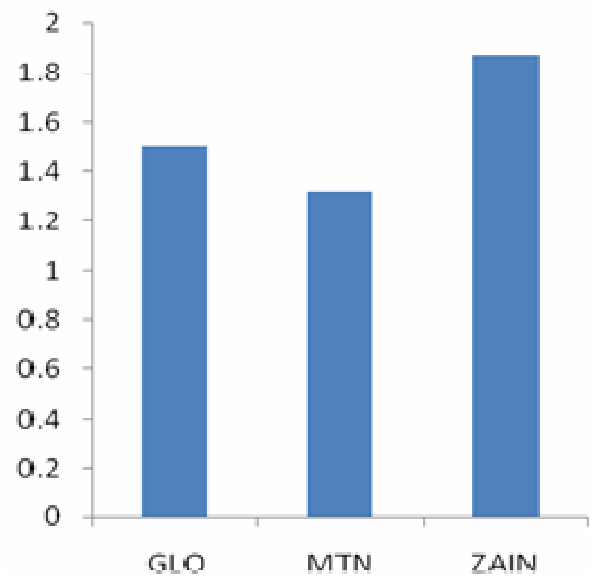

Figure 9. Total radiation measured at 200 m.

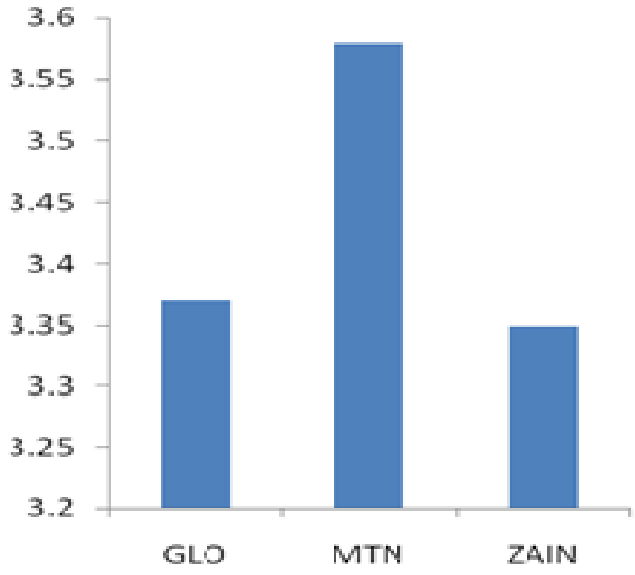

Figure 10. Total amount radiation measured at 100 and 200 m.

correlation or no effect on human health because the low power emission has no sufficient ionization energy to destroy any part of cell in human body. On the other hand it is worthy to say that this work is a preliminary study that used mathematical approach to establish the relationship between RF radiation with Human health, however this study has deficiency to prove biologically that exposure to RF radiation has association with Human health. Therefore, it is recommended for further studies which may requires multi-disciplinary research group to ensure more positive results.

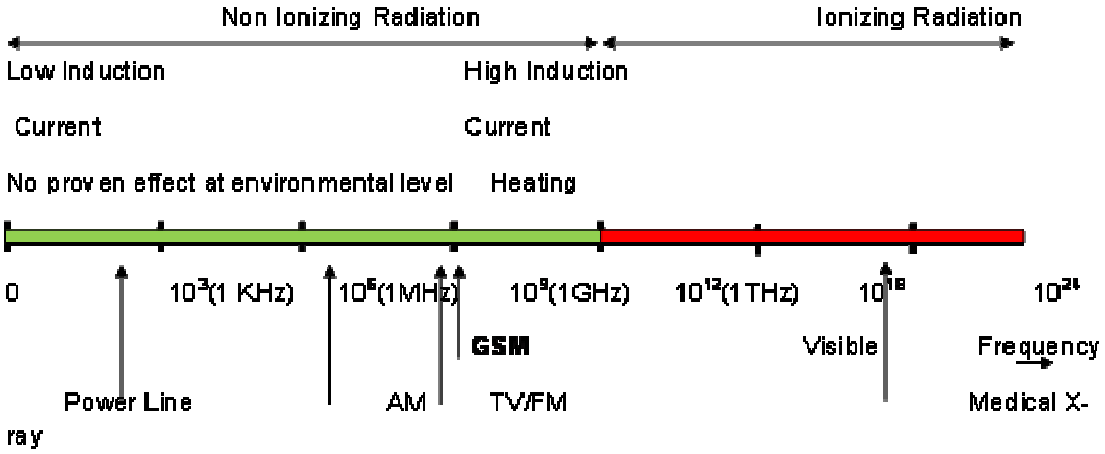

Figure 11. Non Ionizing and Ionizing radiation spectrum (V - Mobile, 2004).

Figure12. ZAIN masts.

Figure 13. MTN masts.

Figure 14. GLO masts.

debate among Nigerian citizen that RF of GSM masts has no effect on human health. The measurement were carried out carefully with precision and the results obtained established that GSM RF has insignificant.

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